International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN(P): 2249-6890; ISSN(E): 2249-8001
Vol. 9, Issue 3, Jun 2019, 613-618

DESIGN AND ANALYSIS OF AIRCRAFT WING SPAR WITH DIFFERENT MATERIALS USING ANSYS

Dr. S. ELANGOVAN[1], Dr. C. SURESHKUMAR[2] & P. DIVYABARATHI[3]

[1]*Dean and Professor, Department of Aeronautical Engineering, Bharath Institute of Higher Education and Research, Tamil Nadu, India*

[2]*Associate Professor, Department of Aeronautical Engineering, Bharath Institute of Higher Education and Research, Tamil Nadu, India*

[3]*Assistant Professor, Department of Aeronautical Engineering, Bharath Institute of Higher Education and Research, Tamil Nadu, India*

ABSTRACT

Aircraft is considered as the complex mechanical invention possessing flying capability. In the structural engineering field, the finest example for the minimum weight design is the structure of the airframe. This efficient design of airframe is achieved by the concept of strength of material approach. The two major parts of the wing is the fuselage and the wing. While considering the wing, the primary load carrying ability is required when the wing is subjected to bending. A typical wing spar is chosen for our study. The study was further enhanced by changing the materials used for wing spar construction. Four different materials were chosen for our study which includes Aluminum, Cobalt, Structural steel and HA. The model was designed using CATIA V5 software and the structural analyses were performed using the ANSYS software packages. The behavior of the spar with different with respect to the applied load at its free end is our observations and the comparative analyses were done among these four different configurations.

KEYWORDS: Static Analysis, Materials, Wing Spar, Deformation & Stress-Strain

Received: Mar 14, 2019; **Accepted:** Mar 04, 2019; **Published:** May 05, 2019; **Paper Id.:** IJMPERDJUN201966

Original Article

INTRODUCTION

In a fixed wing aircraft, the wing comprises of many structural parts including wing spar, stringers, ribs and skin. The spar is considered as the most supporting structural part. The spar is running span wise at right angles to the wing body. The spar is designed in such a way that it could carries the twisted loads also since it carries most of the flight loads as well as the weight of the wings also. It is necessary to carry the twist loads because it is the major reason of the structural failure of the wing. To share the loads of spar, the ribs and stringers were constructed wherever needed. The whole structural parts of the wing should be able to withstand almost all types of the loads including bending, torsion, tensile and compression. These parts define the wing rigidity to fly safely. If a single spar carries major loads then it is termed as the main spar. As per the designing rule, the wing possesses two spars. One spar is placed close to the front portion of the wing. And another spar will be placed near the edge region of the wing. This project only focuses on the wing spar. The wing spar carries around 80% of the load. A spar is actually a beam which extends from wing root to tip region carrying all the compressive, shear and tensile loads. The design of spar is related to all other components. So calculations were carried out based on

reference details. The Spar was designed using CATIA V5 software. The pre and post processing were done using ANSYS packages. The analyses were done for various construction materials. The deformation variation, stress variation and the strain variations were recorded by applying load at single end by considering the wing spar as cantilever beam.

MODELS AND SIMULATIONS

A three dimensional wing spar was designed using the best designing tool called CATIA V5 software. The scaled down model of wing spar was actually designed and the length of the spar is 1.5m.

The CATIA model is then imported in to ANSYS work area to do discretization stage of the model. Discretization is actually a process of splitting a computational model into a number of smaller nodes to make simulations easier. A fine and good meshing is generated around the spar to capture even a small change over the spar due to the application of load.

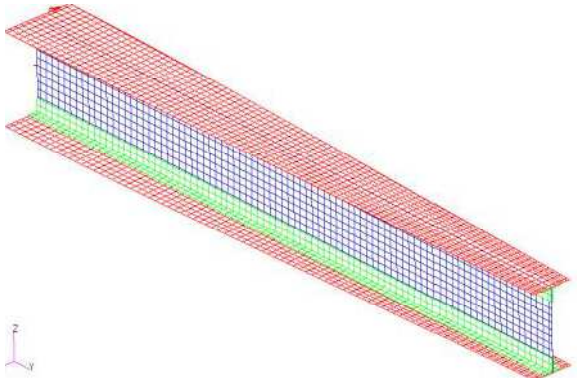
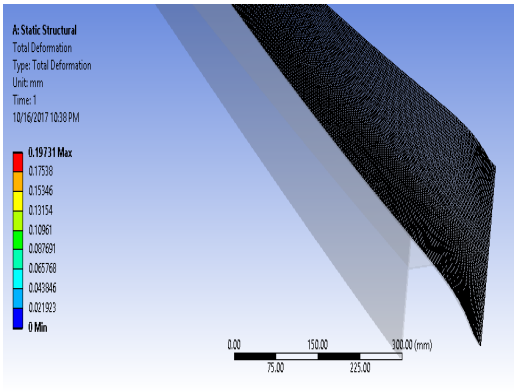


Figure 1: Discretized Wing Spar Model

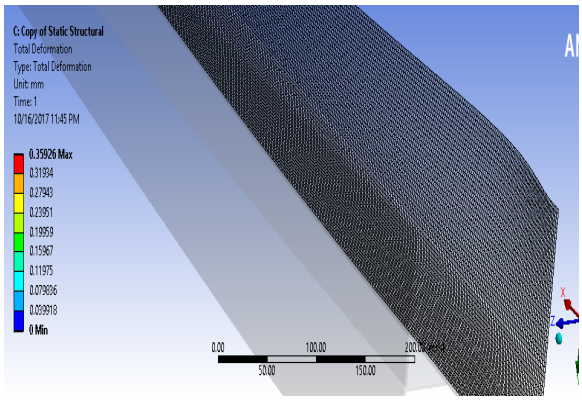
RESULTS AND DISCUSSIONS

The discretized wing spar model was imported into the ANSYS work area and the load value of 1727kgwas applied. The boundary conditions are now applied to the wing spar model. The wing spar was considered as the cantilever beam. One end is considered as fixed and the load was applied to the other end that is the free end by constraining all the six degrees of freedom. The loads were applied and the corresponding deflection was recorded. Along with the deflection the stress and strain values were also observed. The stress values, strain values and the deformation values were calculated for the spar with the four different materials and were shown in the following images.

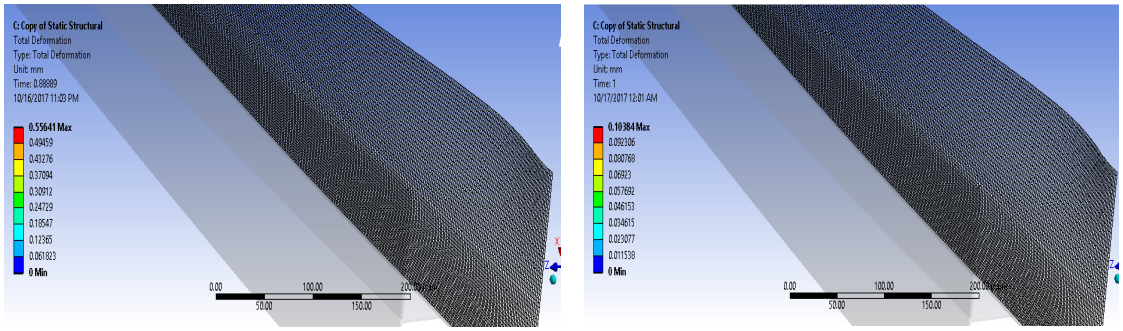
Deformation Contours of Spar with Different Materials



For Aluminium



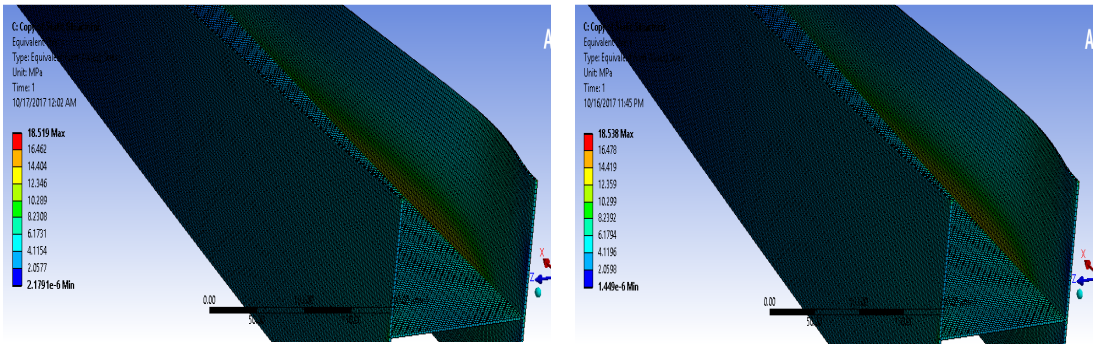
For Cobalt



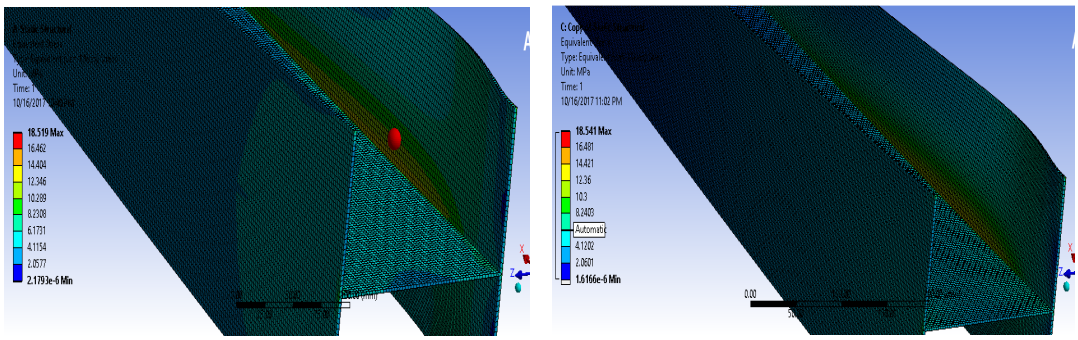
For Structural Steel **For HA**

Figure 2: Deformation Contours of Spar with different Materials

Stress Contours of Spar with Different Materials



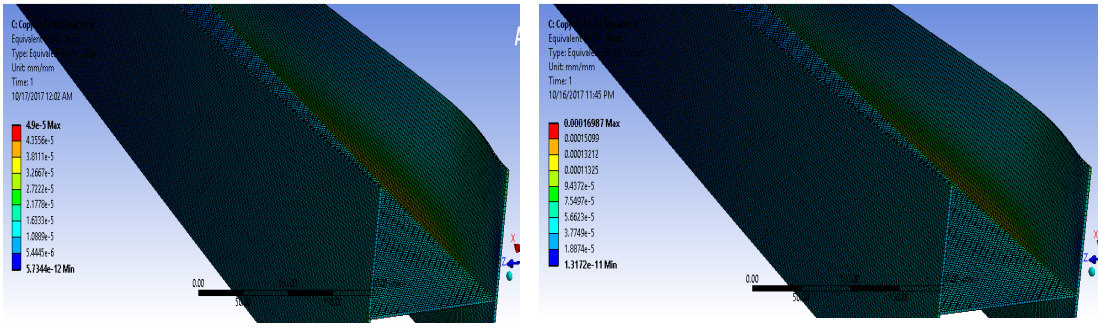
For Aluminium **For Cobalt**



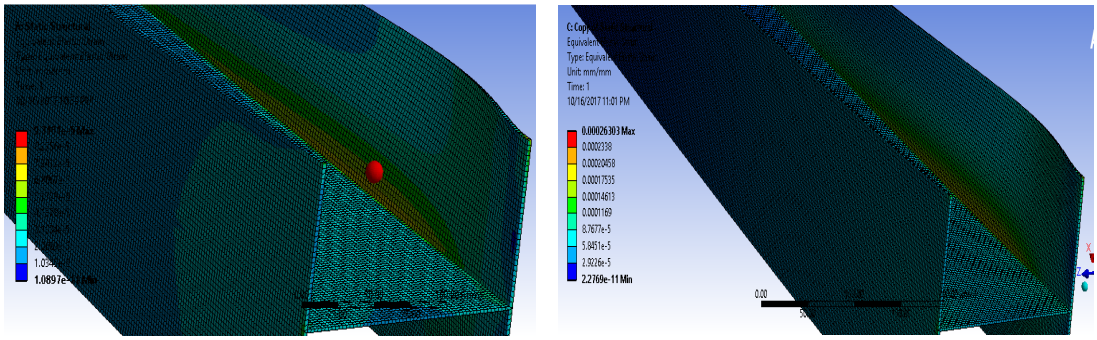
For Structural Steel **For HA**

Figure 3: Stress Contours of Spar with different Materials

Strain Contours of Spar with Different Materials



For Aluminium **For Cobalt**



For Structural Steel **For HA**

Figure 4: Strain Contours of Spar with different Materials

CONCLUSIONS

Wing spar was actually designed based on the strength of materials approach. It is designed for minimum weight. Finite Element Analysis approach was used to analyze the stress, strain and deformation factor in the selected structure. Comparative analyses were done to select the better material which shows maximum strength parameters. The maximum deflection takes place at the tip region of the wing spar. Static analysis was carried out in the wing spar. In the future studies, the weight can be reduced by introducing cut outs in the web portion of the spar.

REFERENCES

1. *N. Maheswaran, S.P. Venkatesan, M.S. Sampath Kumar, & G. Velmurugan Study of weight optimization on Spar beam for the wing of an Aircraft Department of Aeronautical Engineering, Excel Engineering College Tiruchengode, Tamil Nadu, India. ISSN: 2347- 4890, Volume 3, Issue 3, March-2015.*
2. *Ghassan M. Atmeh, Zeaid Hasan, Feras Darwish Design and Stress Analysis of a General Aviation Aircraft Wing Jordan University of Science and Technology, Irbid, Jordan.*
3. *Immanuel D, Arulselvan K, Maniiarasan P, & Senthilkumar S Stress Analysis and Weight Optimization of a Wing Box Structure Subjected to Flight Loads Department of Aeronautical Engineering Nehru Institute of Engineering and Technology, Coimbatore, Tamil Nadu, India. ISSN: 2319-1813, Volume 3, Issue 1, September-2014.*
4. *Guguloth Kavya, & B.C. Raghukumar Reddy Design and Finite Element Analysis of Aircraft Wing Using Ribs and Spars Department Of Mechanical Engineering, Malla Reddy College Of Engineering, Hyderabad, Telangana, India. ISSN: 2348-4845, Volume 2, Issue 12, November-2015.*
5. *Mohamed Hamdan A, & Nithiyakalyani S Design and Structural Analysis of the Ribs and Spars of Swept Back Wing Department of Aeronautical Engineering, Srinivasan Engineering College, Perambalur, and India. ISSN: 2250-2459, Volume 4, Issue 10, and December-2014.*
6. *Arockia Ruban M, Kaveti Aruna, & Puneet Kumar S Structural Weight Optimization of Aircraft Wing Component Using FEM Approach Stress Analysis Department, Jetwings Technologies, Bangalore, India. ISSN: 2248-9622, Volume 5, Issue 6, June-2015.*
7. *Ambri, & Ramandeep Kaur Spars and Stringers - Function and Designing Department of Aerospace Engineering, Gurukul Vidyapeeth Institute of Engineering& Technology, Jamnagar, Banur, Karnataka, India. ISSN: 2393-8609, Volume 1, Issue 1, September-2014.*

8. *Vinoth Raj. A, & Raghu. T Topology Design Optimization of Ribs, Spars, Wing Attachment Bulkhead and Nose Landing Gear Bracket Design Engineer, Advanced Research Institute - R&D Centre, Dr. M. G. R Educational And Research Institute University, Chennai, Tamil Nadu, India. ISSN: 2321-3051, Volume 3, Issue 10, October-2015.*
9. *Abbani Rinku, Prashanh R, & Naveen Kumar. R. O, Structural Optimization of typical light transport aircraft component Scientist at C-CADD, NAL Bangalore, Karnataka, India.*
10. *Vinod S. Muchchandi1, & C. Pilli Design and Analysis of A Spar Beam For The Vertical Tail of A Transport Aircraft Department of Mechanical Engineering, KLE Dr.MSS CET, Belgaum, Karnataka, India. ISSN: 2319-8753 Vol. 2, Issue 7, July-2013.*
11. *Matharou, G. S., Bhatia, S., & Tanzeel, M. Comparative Study Of Sae 1141 Carbon Steel, T651-7075 Aluminum Alloy & 4340 Billet Steel Material For Connecting Rod Using Ansys 16.*
12. *Andrejs Kovalovs, Evgeny Barkanov, & Sergejs Gluhihs Active Twist Of Model Rotor Blades With D-Spar Design Institute of Materials and Structures, Riga Technical University, Azenesst, Latvia. ISSN: 1648-4142, Volume 12,issue 1.*
13. *Muhsin J. Jweeg, Dr. Shawkat J. AL-Tornachi, & Salah H. Abid-Aun Optimization of Light Weight Aircraft Wing Structure Department of Mechanical Engineering College of Engineering Al-Nahrain University, Baghdad, Iraq. ISSN: 1813-7822, Volume 12, Issue 1, March-2009.*
14. *M. Kaufmann, T. Czumanski, & D. Zenkert Manufacturing process adaptation for integrated cost/weight optimization of aircraft structures KTH Royal Institute of Technology Stockholm, Sweden. Volume 38, Issue 2, March-2009.*
15. *Sheikh Naunehal Ahamed, Jadav Vijaya Kumar, & Parimi Sravani Weight Optimization of Empennage of Light Weight Aircraft International Journal of Scientific & Technology Research. ISSN: 2277-8616 Volume 3, Issue4, April-2014.*
16. *Graeme J. Kennedy, & Joaquim R. R. A. Martins A Comparison of Metallic and Composite Aircraft Wings Using Aero structural Design Optimization Department of Aerospace Engineering, University of Toronto Institute for Aerospace Studies, Toronto, Canada.*